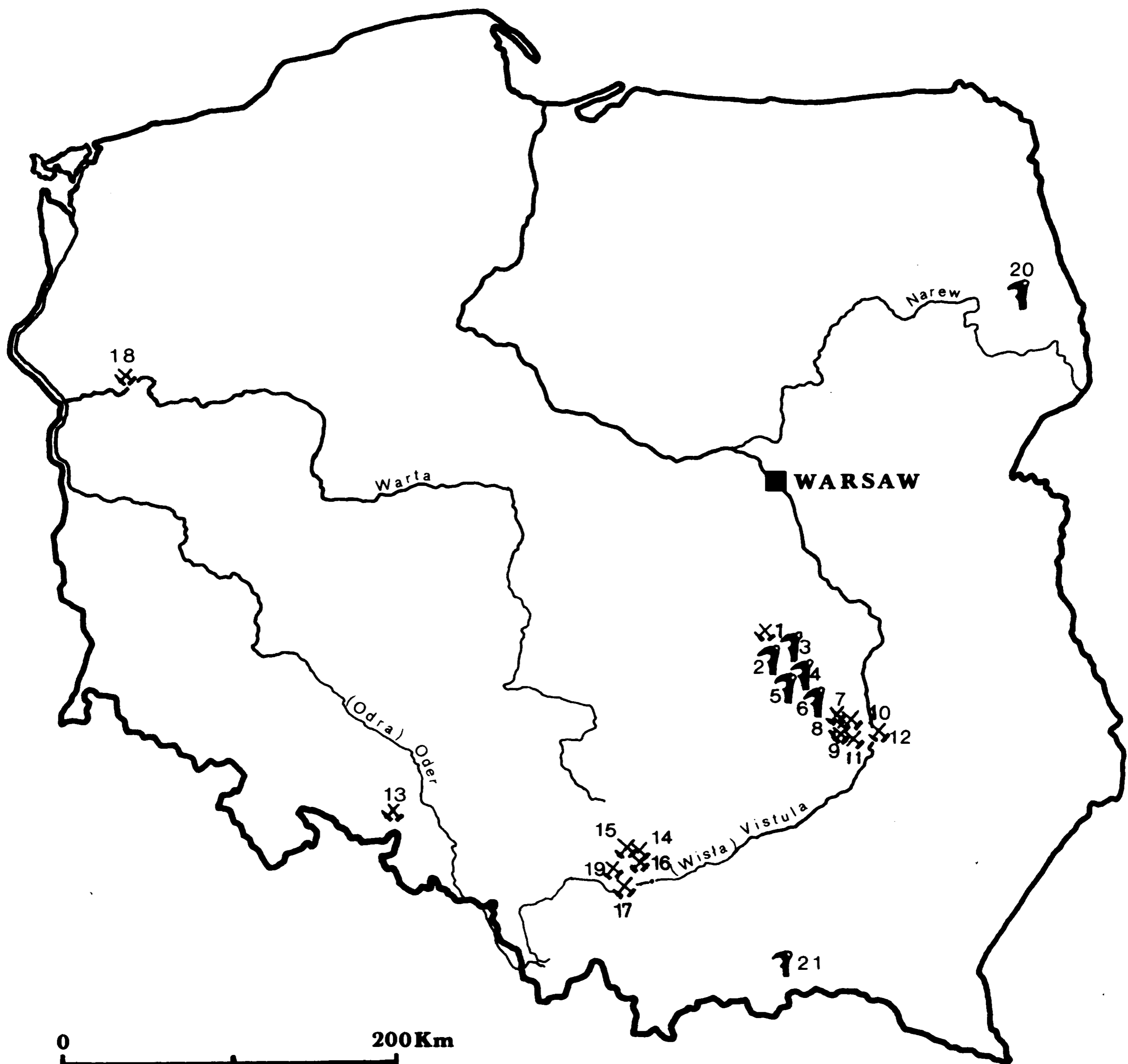


**PL 6 Krzemionki, Kielce Province.  
Prehistoric flint mines complex in  
Krzemionki (Kielce Province)**

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## **PL 6 KRZEMIONKI, KIELCE PROVINCE**

### **Prehistoric flint mines complex in Krzemionki (Kielce Province)**

**Wojciech Borkowski**

#### **HISTORY OF STUDIES AND BASIC LITERATURE**

There is abundant literature on the studies in Krzemionki (Bąbel 1975:149–77; Sałaciński and Zalewski 1987:10–4; Borkowski *et al.* 1989:64–207).

The mines' discoverer J. Samsonowicz studied the geology of the Opatów region, eventually producing a 1:100,000-scale geological map (Samsonowicz 1934). Samsonowicz correctly interpreted the mining excavations he observed in a quarry face,

and also suggested that a previously discovered feature in Borownia was also the work of miners. Further work led to the plotting of the course of striped flint outcrops.

The first researcher to devote a lot of time to Krzemionki was J. Żurowski, who must be credited for determining the approximate range of exploitation and for the first descriptions of subterranean excavations. His explorations concentrated in the north-eastern part of the mining field which was completely destroyed by a stone quarry at the time of Żurowski's work. It was there that he excavated one of the shafts (so called "Well II") and explored a fragment of its mining fronts. Unfortunately, no general analysis of all his observations was produced.

The most wide-ranging research program at Krzemionki was no doubt implemented by S. Krukowski. This archaeologist worked intensely to localize striped flint outcrops, and by registering concentrations of finds he defined approximately the region in which natural outcrops are to be found. Krukowski was the first to appreciate and publicly announce the significance of Krzemionki (Krukowski 1932:58–9). From 1927 intermittently he carried out studies and surveys of Magonie, Krzemionki and the immediate vicinity. His main objective was the creation of an archaeological reserve and scientific station in the area occupied by the villages of Krzemionki, Magonie and Stoki Stare. For over ten years he documented the accessible underground excavations. He started his own dig in the area near mines 1, 2 and 3, and studied flint workshops in various parts of the field, amassing a vast collection of flint artifacts and mining tools. He salvaged and later classified voluminous flint material that was being plundered from the workshops by local peasants. He surveyed and mapped settlements around Krzemionki, and he systematically gathered collections of artifacts from the already discovered settlements. The consistent pursuit of his program eventually led to the fundamental work *Krzemionki Opatowskie* (Krukowski 1937, 1939). Although the work did not take into account the entire body of data accumulated by its author, it was nevertheless far ahead of any other analysis of those times.

M. Drewko and T. Żurowski who came next were concerned primarily with conserving the site, organizing an archaeological reserve and opening it to tourists; excavations were for them of secondary importance. The results of their work were reported in a number of publications which are little more than of documentary value (Żurowski 1960, 1962).

The next explorer of Krzemionki, J. Bąbel, commenced soundings spanning the entire width of the field, close to an arbitrarily drawn line referred to as the "thoroughfare." Regrettably, this project was not completed, and only the pit mine 6/668 was explored thoroughly. The results of this research were sketched in just one publication (Bąbel 1986:27–42). The flint materials and the entirety of data obtained during the archaeological explorations are yet to be published.

The efforts of individual explorers could not be expected to bring satisfactory results, and in 1985 the State Archaeological Museum created a research team for work at Krzemionki. This team was headed by S. Sałaciński (1985–1987), the present author (1988–1989), W. Migal (1990–1992) and currently again by the present author. In addition to the above archaeologists, the team also includes M. Zalewski.

In 1986 the team presented its research program (Sałaciński 1987:257–62). Plans called for a parallel tackling of four problem groups:

- exploration of mining work systems in the Krzemionki exploitation field (Migal 1990:197–9);
- reconstruction of the deposit exploitation systems in the various parts of the mining field (Borkowski 1990:225–31);
- comprehensive analysis of production activities based on the raw material extracted from the mines in Krzemionki (Sałaciński 1987:258–9);
- analysis of the relationships between the striped flint economy system and the settlement network around the Krzemionki mines (Zalewski 1990:233–8).

The findings of the team concerning exploitation, processing and distribution of striped flint are reported in a number of detailed works (including (Borkowski *et al.* 1989:164–207, 1991:607–27).

## THE KRZEMIONKI EXPLOITATION FIELD

The traces of mining activity visible on the ground surface form a belt extending for about 4.5 kilometres (measured along its center line) and varying in width from about 25 m. in the north-eastern part to some 220 m. in the northern extremity of the mining field (Fig. 1). The borders of the field shown in the sketch are defined by rubble tips and shaft depressions discernible on the ground surface.

Aside from mines, the exploitation field also contains remains of flint workshops and domestic features (camps). It seems that the distribution of the latter two kinds of features is governed by the distribution of mines.

When discovered, the mining field belonged to three villages: Krzemionki, Magonie and Stoki Stare. Today the field is part of the Krzemionki Archaeological reserve administered by the Historical and Archaeological Museum in Ostrowiec Świętokrzyski.

In the past the exploitation field was overgrown with forest. Starting from 1911, a gradual deforestation began and proceeded intermittently as the newly created village of Krzemionki grew. The deforested land was taken over for agriculture. The complete clearance of the forest from a large expanse of the mining field was a very

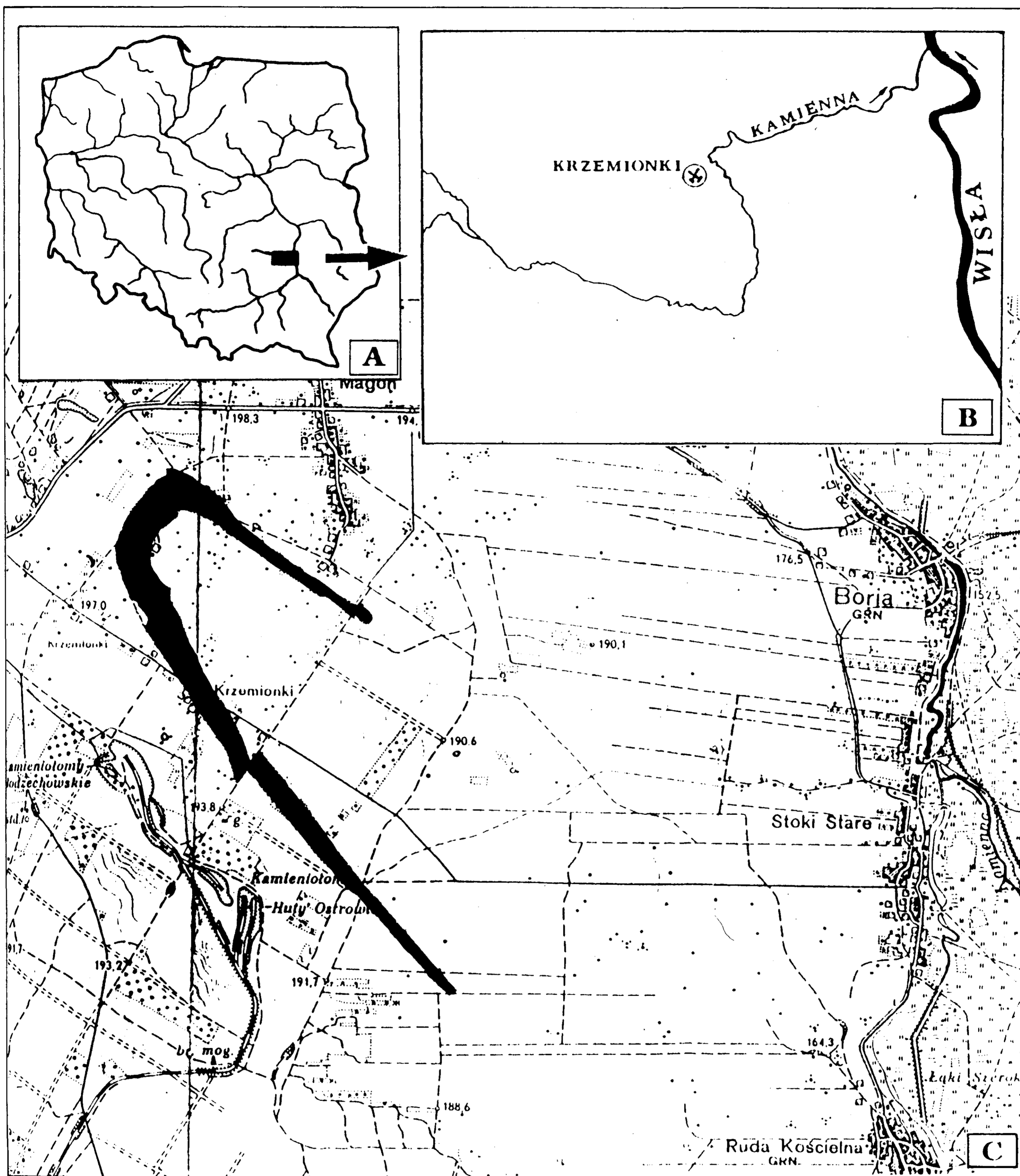


Fig. 1. PL 6 Krzemionki. Location of the exploitation field.

brief episode and ended in 1933–1934 when Krukowski began buying up the land to turn it over to the future reserve. Since that time the exploitation field began to be taken over by forest in a natural way. Its fringes were sporadically tilled and there was some deforestation. Today the entire field and adjacent territories are covered with a naturally growing mixed forest.



The greatest destruction of the Krzemionki exploitation field is definitely the work of local inhabitants extracting the local limestone. In the period from 1914 to 1953 they went mainly after the layer of oolitic limestone forming the roof of the mining excavations.

A number of farm buildings belonging to the Krzemionki and Magonie villages existed on the exploitation field in various periods, and during the Second World War three lines of trenches were dug across it by soldiers.

## GEOLOGY OF THE DEPOSIT

The Krzemionki exploitation field lies in the north-eastern part of the Mesozoic perimeter of the Holy Cross Mountains, to be exact — at the north-western tip of the Jurassic Magonie-Folwarczysko basin formed by Early Kimmeridgian orogenic movements (Borkowski and Michniak 1992:11–3).

Recent studies showed that this basin (at least in the Krzemionki area) is transversally cut by tectonic faults (Borkowski and Michniak 1992:13–5) which divide the field into three segments, each of which is geologically distinct. As can be seen from the geological structure of rocks containing striped flint beds in Krzemionki, in spite of the differences in structure of the various segments, the principal geological profile remains the same (Fig. 2). What changes is the dip angle of the rock layers which affects the width of the exploitation belt. The layers dip towards the center of the basin (parabola focus) at angles not exceeding  $5\text{--}7^\circ$ , except in the north-eastern branch of segment B (highest part) where this angle increases to  $22\text{--}30^\circ$ .

In all segments of the exploitation fields, the geological-engineering situation in the deposit is similar. The factor responsible for shaping the technical conditions in rock forms is surface weathering. With this factor in mind, we may distinguish four layers in the part of the deposit of interest to us.

Going downwards from the outcrop, the flints of the upper bed are first encountered in a layer of sandy clay and limestone rubble. This layer reaches a depth of between 2 and 3.5 m. Next, the upper bed occurs in a layer of severely cracked rock. The lower limit of this rock formation is 4.5 to 5 m below ground level. Finally, we see the flints in slightly cracked rock masses reaching down to a depth of about 6 or 7 m. Deeper down in all layers we reach monolithic rock.

Based on explorations of the various mines and observed general regularities, we have determined the systems of mining work in the various deposit layers (Fig. 3). In what follows we give a general presentation of these systems; several publications treat the subject in greater detail (Migal 1990; Borkowski *et al.* 1989, 1991).

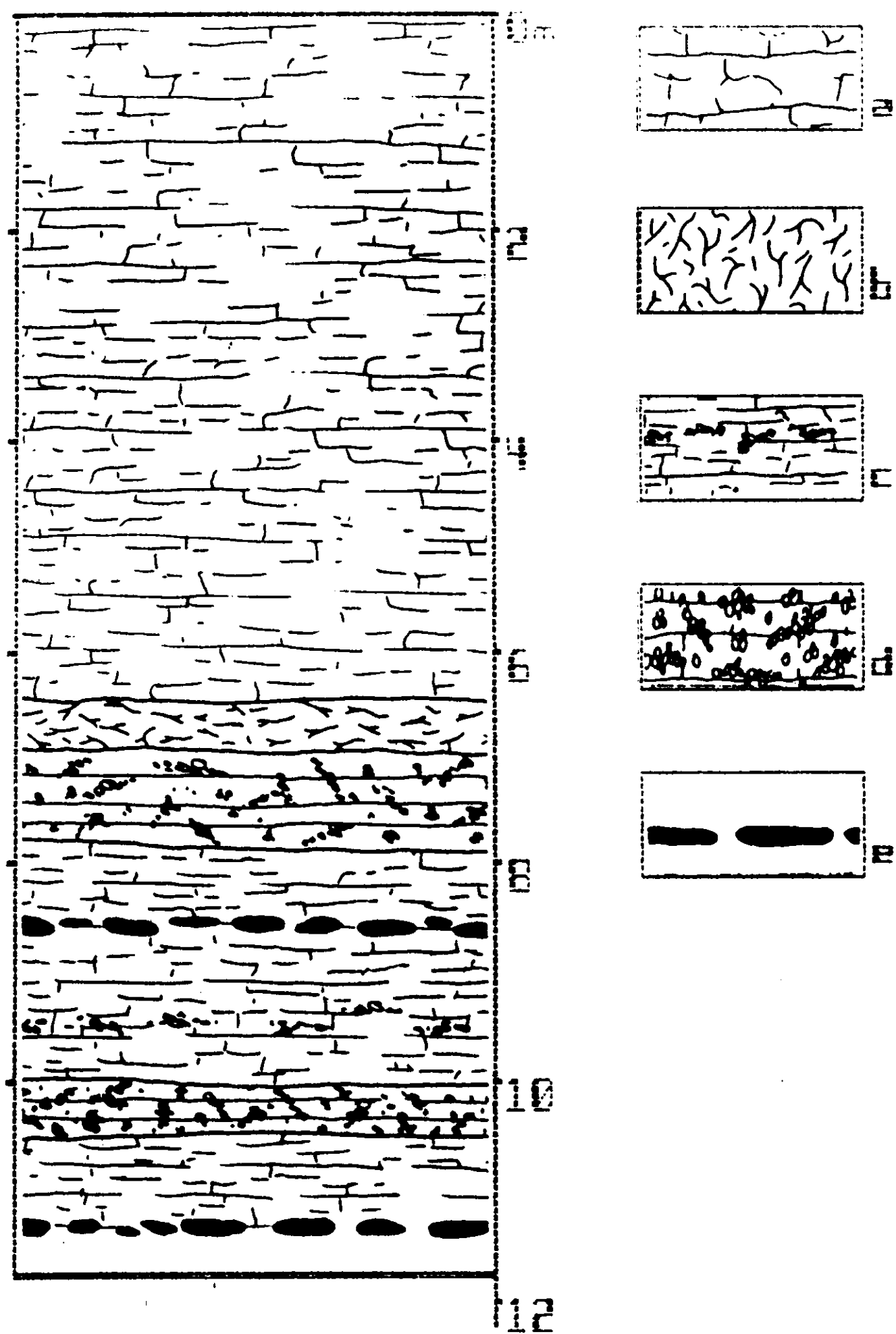


Fig. 2. PL 6 Krzemionki. Geological profile of Jurassic rock in Krzemionki: a — pelitic limestone; b — coral limestone; c — pelitic limestone with oolites; d — oolitic limestone; e — striped flint beds.

wooden tools. Soil and rock was loosened with unprocessed roe deer antlers and flint hoes and picks. The excavated material was deposited in adjacent mines and in exploited niches.

### NICHE MINES

This system was resorted to in the layer of severely cracked (loose) rock. The mines were up to 4.5 m. deep and offered greater exploitation possibilities by allowing the miners to dig horizontal niches into the shaft wall (up to 2 or 2.5 m deep). The diameter of the mine shaft itself was relatively large (up to 4.5 m). It is estimated that about 50% of all the raw material was excavated from the niches. Thus, compared with the strip mines, the niche units represent a shift in emphasis to exploitation of underground excavations.

### STRIP MINES (SIMPLE PITS)

Strip mining served to extract flint from the very loosely packed clay and rock rubble layer. The mines were pits of various diameter, 3 to 3.5 m deep. They are referred to as pit mines. The shaft openings widened funnel-wise at the top, reaching diameters of up to 4.5–5.0 m on the ground surface.

In deeper mines of this kind the exploitation area was increased by digging small niches in the shaft walls, not deeper than 1 metre. However, according to estimates, more than 90% of the raw material was extracted from the bottom of the shaft.

The area that could be exploited was limited by two factors:

- the angle of shaft wall slip near ground surface; and
- cohesion of the rock mass in the bottom part of the shaft conditioning the safe size of niches.

Since the rock mass was loose, the miners probably used a variety of



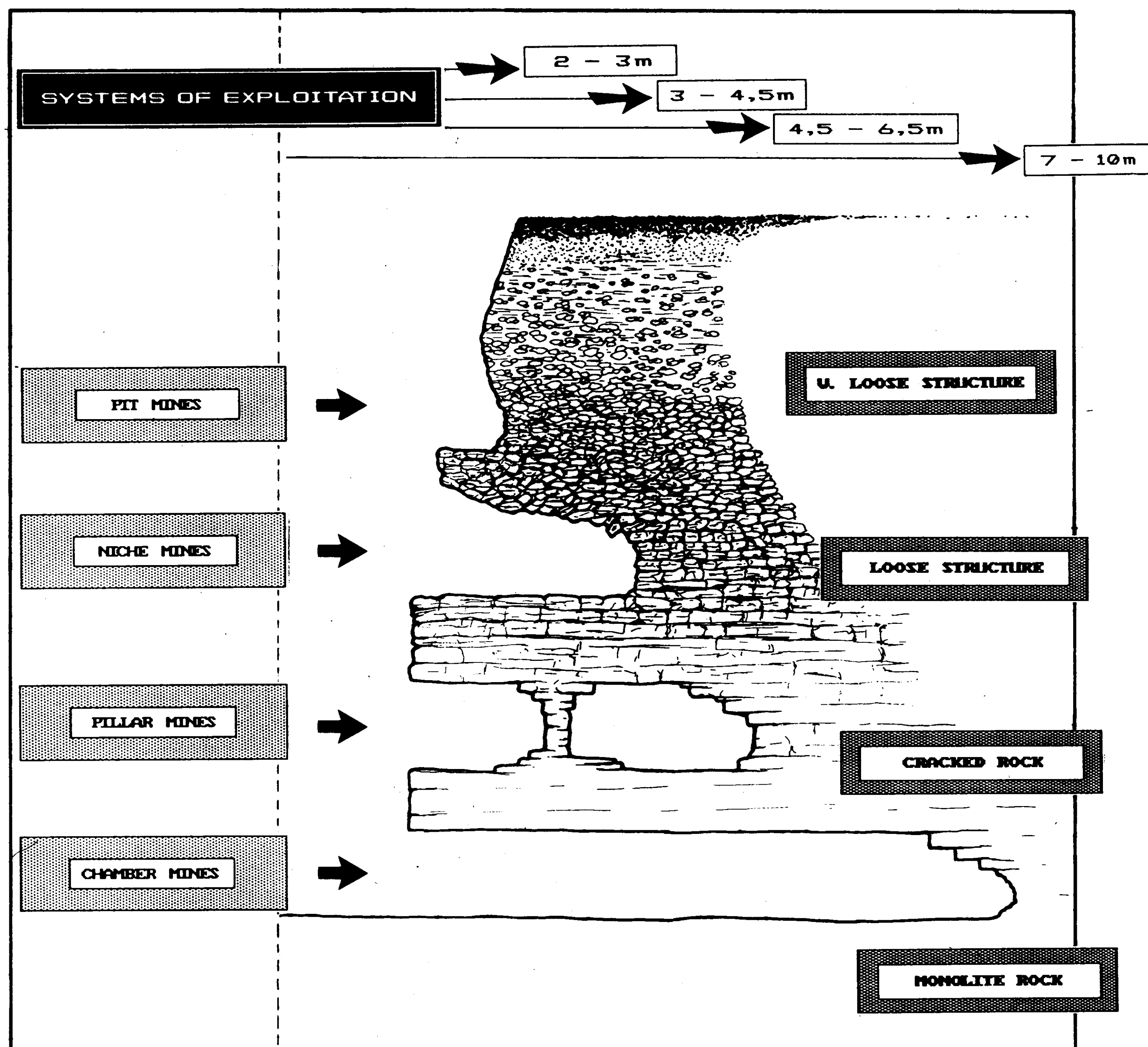


Fig. 3. PL 6 Krzemionki. Different system of flint exploitation depending on geological-engineering conditions of deposit.

The size of niches was limited by safety considerations and depended on the cohesion of the rock mass forming their roofs. The time it takes for this roof to dry up directly determined niche size. Accordingly, work conditions could have improved as the depth of flint deposition increased.

This type of exploitation differed markedly from the previous one in that the miners made use of transverse radial cracking (cleavage) of the rock mass and in their excavations proceeded along the fissures.

The mining tools set included flint picks used in the upper layers, but the most important implements were antler levers and wedges as well as numerous carefully selected natural volcanic rock fragments. The latter were hammered into the fissures to loosen up the rock mass.

The system of rock working required total specialization. Vertical cracks were propagated and rock blocks of various size extracted. The mined rock was at first deposited around the mine opening and in disused mines close by, and in the final stages used to fill in the abandoned exploitation niches.

## PILLAR MINES

The pillar mines were sunk to exploit the deposit in the layer of uncracked rock. The cohesion of the rock mass in this layer made possible multi-seasonal work. In these mining units the bottom of the mine shaft completely lost its significance as a place of exploitation in favor of underground excavations. The shaft became purely a means of access to the deposit and a transportation route. Its diameter did not exceed 3 m.

The cohesion of the excavation roof enabled the miners to work at considerable distances from the shaft wall (5 to 9 m). It seemed these distances depended on organizational considerations, and chiefly on the limited possibilities of providing ventilation. In order to reinforce the mine roofs, the miners left unexcavated rock pillars (close to the shaft).

The tools used in mines of this kind included diverse antler implements (such as wedges, levers, hammers and chisels) and also lithic wedges resembling

quadrangular axes made from volcanic rocks (diabases and amphibolites) (Fig. 4).

Work in the pillar mines consisted basically in expanding the existing cracks and fissures. Miners followed the general direction of rock mass cracking (cleavage). The straight galleries that resulted were sometimes up to 2.5 m long. In the space between adjacent mines the miners sometimes left large sections of unexcavated rock mass if these were not visibly cracked and did not contain flint nodules. The uncracked rock was worked in two stages. First, the miners hacked out a niche low down and then tried to pry out its roof. Mining work proceeded more or less evenly in all directions, the general rule was that the direction of

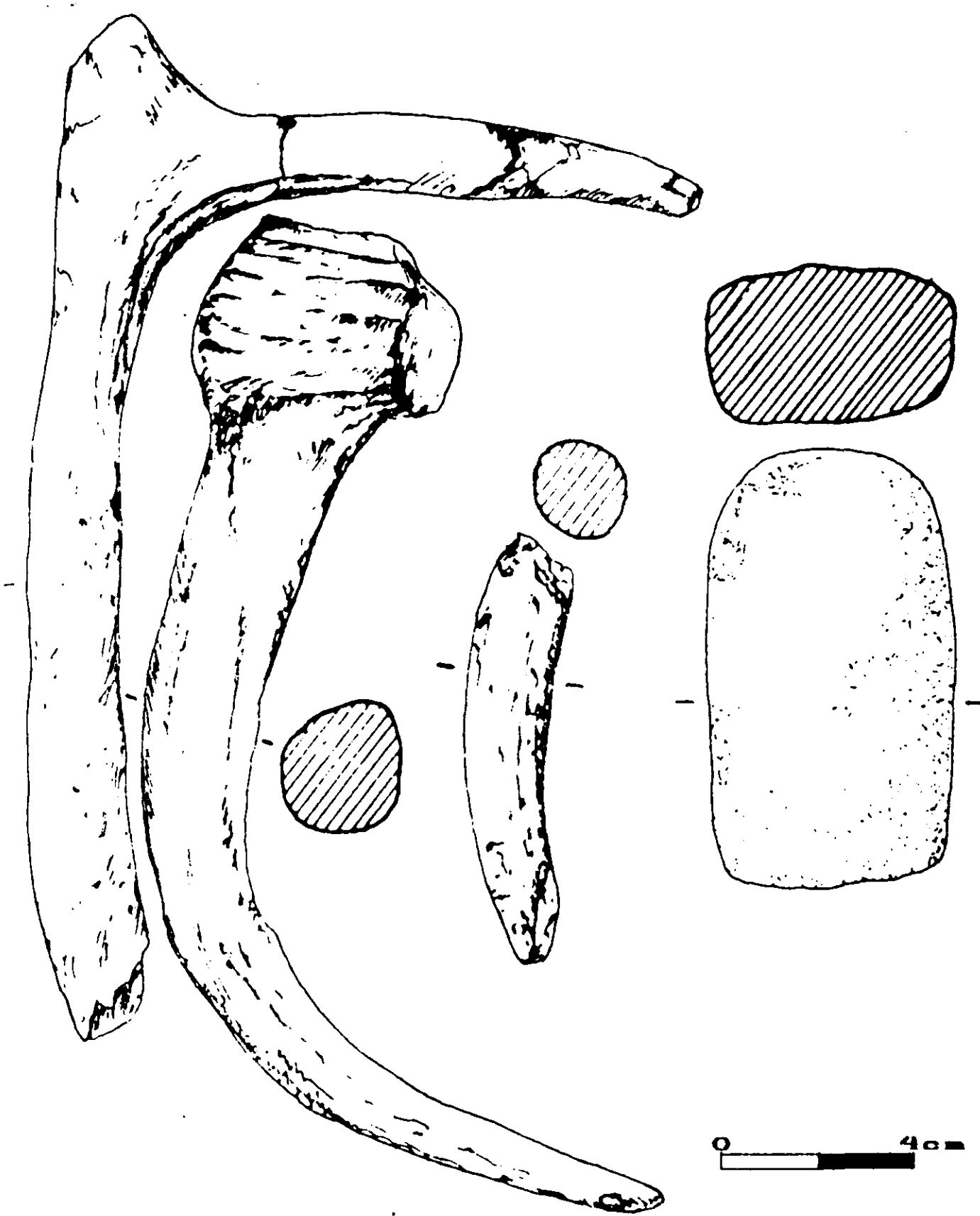


Fig. 4. PL 6 Krzemionki. Tools from pillar mines.

cracks were followed. The rubble was deposited in abandoned galleries and on a tip around the shaft opening. The extracted rock was also used to fill in the shafts of abandoned mines (Fig. 5).

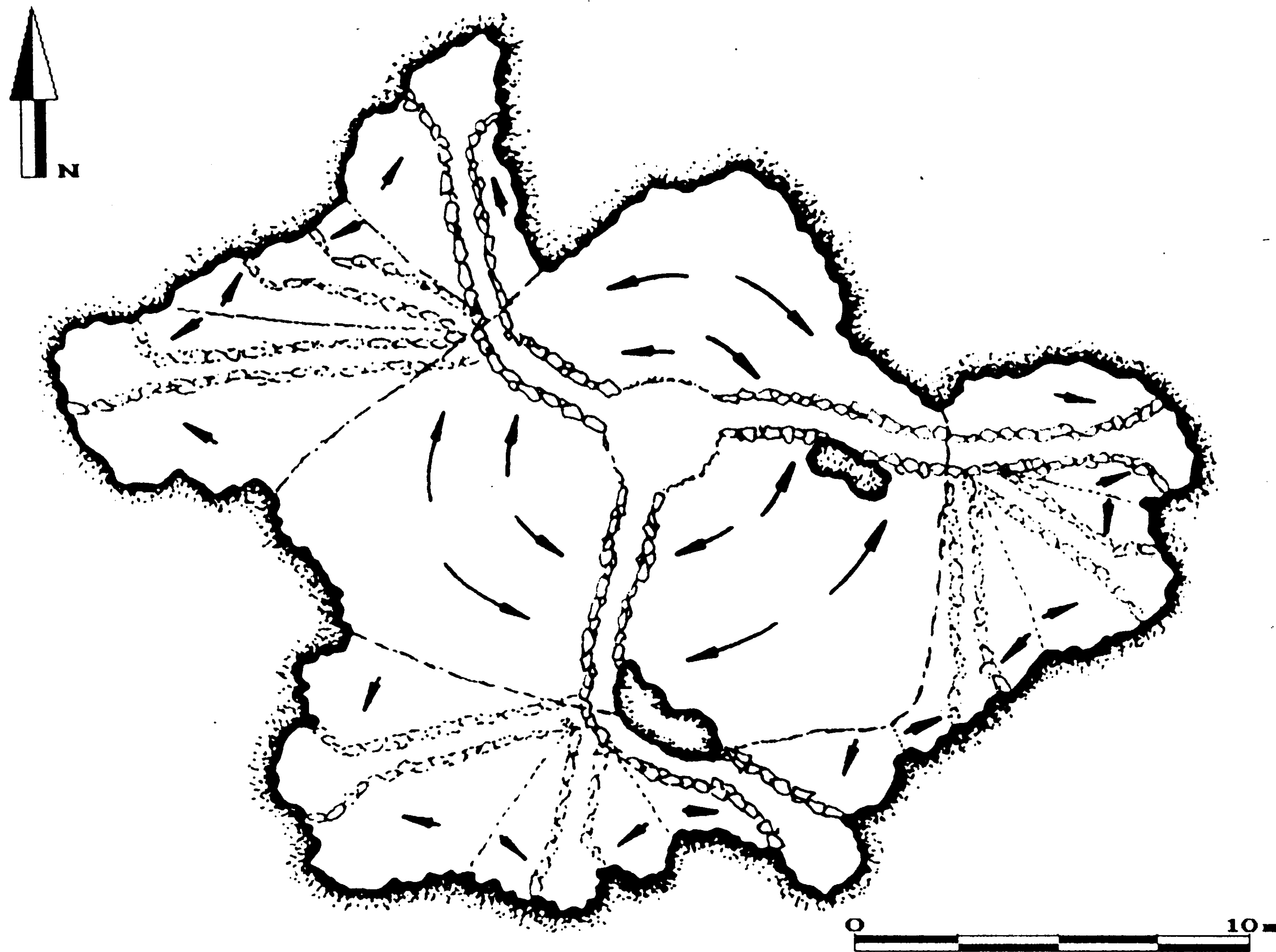


Fig. 5. PL 6 Krzemionki. Organization of work in pillar mines.

#### CHAMBER MINES (Figs 6–8)

The deep chamber mines exploited the flint deposit in the solid rock layer. The monolithic rock forming gallery roofs was strong enough to make the reinforcing pillars redundant. The sections of rock that were left unexcavated contain no flint concretions and were bypassed by miners for purely economic reasons.

In working the rock mass the miners made use of its lamellar structure. Small niches were hacked out above the flint concretions in poorly layered rock, and then a variety of flint wedges were inserted between the rock layers to detach large limestone plates.

A new kind of tool appeared in these mines, cigar-shaped, thick cylindrical pickaxes with a sharp point and blunt head. There were also numerous flint wedges

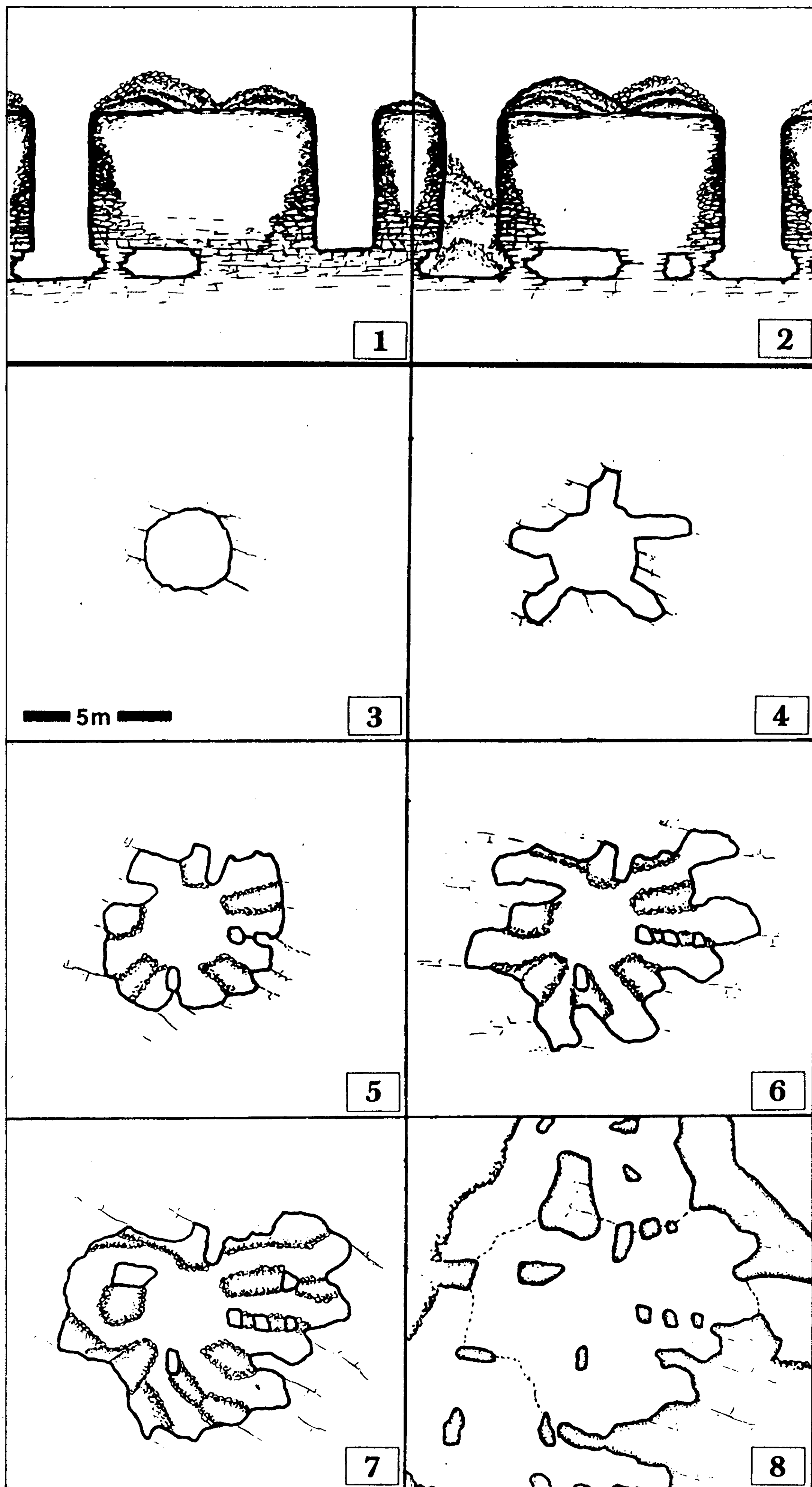


Fig. 6. PL 6 Krzemionki. Map of chamber mine showing the directions of work.





Fig. 7. PL 6 Krzemionki. Chamber mine

made from natural concretion fragments as well as flint hammerstones. Antler tools formed a small percentage of the assemblage.

Of practical significance was the raw material mined in the underground excavations; the mine shaft diameter did not exceed 3 m. The excavated chambers could be as large as 400 m<sup>2</sup> in area, which is understandable considering that these mines were operated for a number of years. The area where mining work would be done was not limited by safety considerations. The miners also solved the problem of ventilation: a system of small fires (probably oil lamps) was used to force air movement in the excavations. Limitations were however created by mined material transport. Waste rock was deposited in exploited parts of the mine, using a complex but highly efficient system of rubble management. Selected





Fig. 8. PL 6 Krzemionki. Chamber mine

excess rubble was removed to tips around the shaft mouth or dumped into earlier abandoned mines. However, the constantly increasing transport distance led to pile-ups of redundant material at a certain, fixed distance between the mining front and the shaft (Fig. 6).

The mining systems presented (very sketchily) above were distinguished not on the basis of mine form differences, as is the case in most analyses, but in view of differences in mining techniques. As can be seen, these resulted from a strict adaptation to engineering conditions in the various deposit zones. The shape and size of excavations were just another consequence of the system rather than the result of a preconceived pattern. Nonetheless, the system was obviously subject to strict determination.



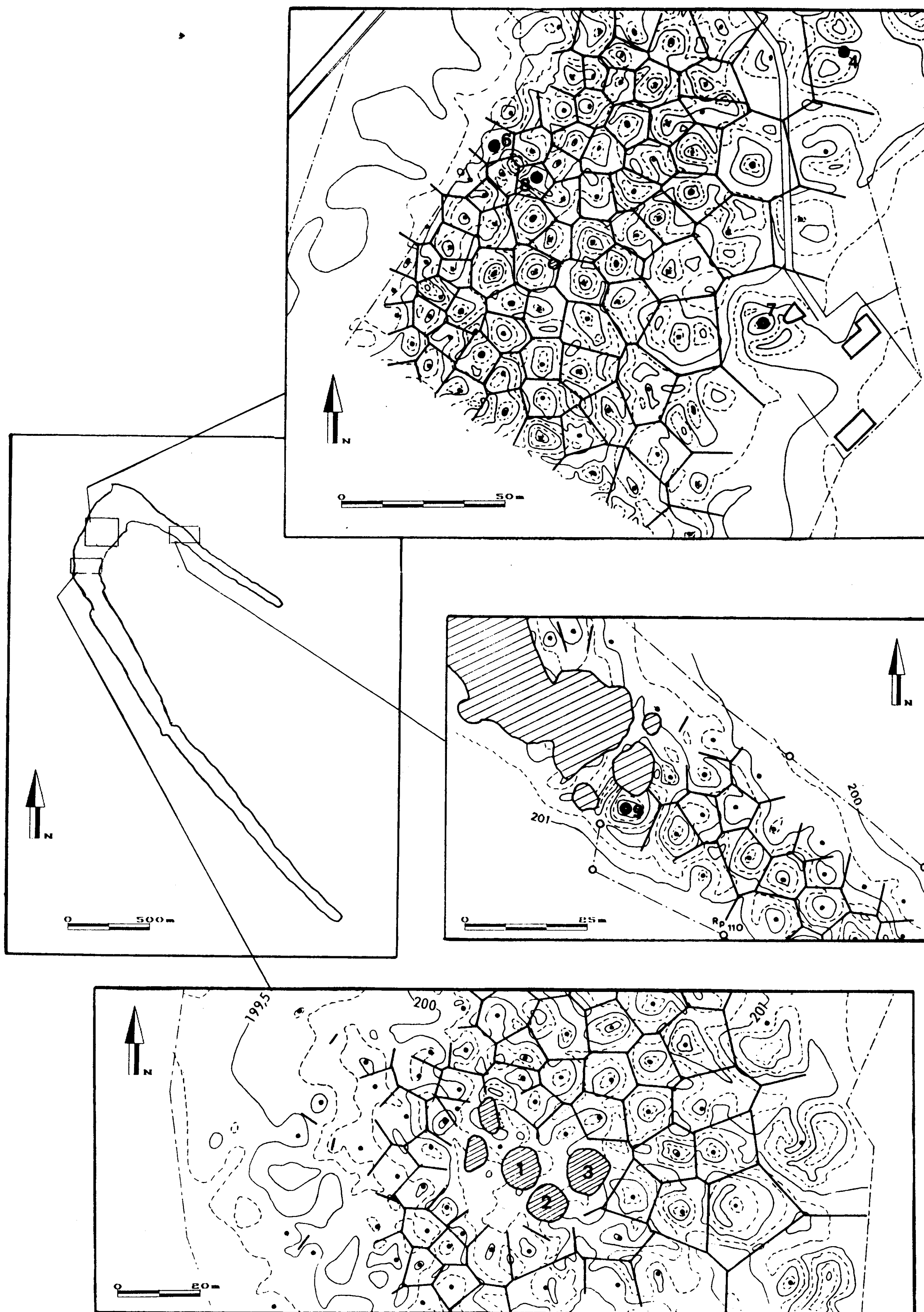


Fig. 9. PL 6 Krzemionki. Fragments of the polygon map of the exploitation field.

## SYSTEM OF DEPOSIT UTILIZATION

The extent of subterranean mining, limited by all the factors described above, is indicated on the ground surface by the distribution of mines (Fig. 9). A reconstruction of the system of deposit utilization in the various parts of the mining field was achieved based on the density and distances between mines represented by a Thiessen polygons network (Figs 10–11).

In general terms, the system at Krzemionki called for the exploitation of the

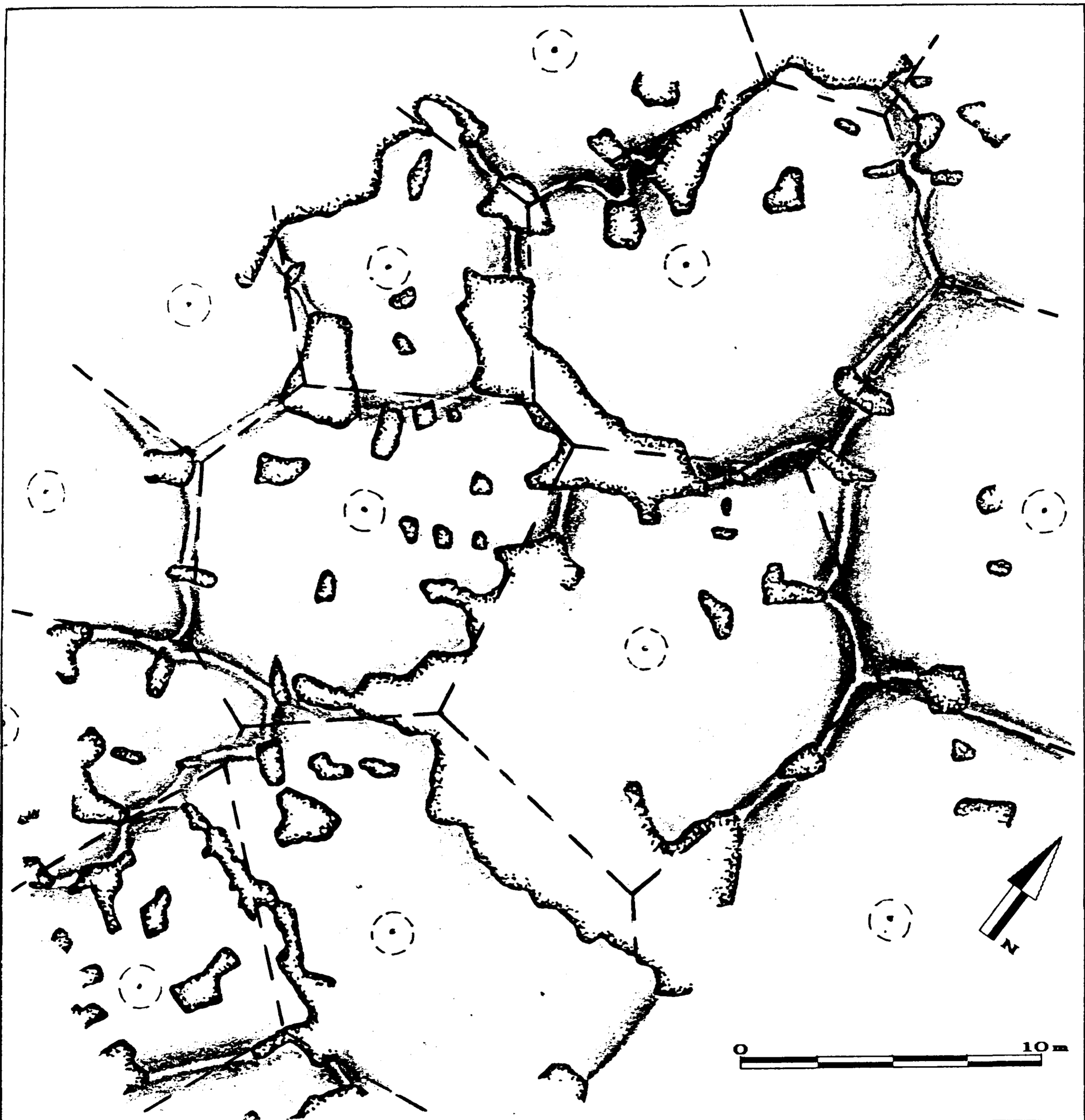


Fig. 10. PL 6 Krzemionki. Map of mine excavations in one of the segment of exploitation field with superimposed network of Thiessen polygons.

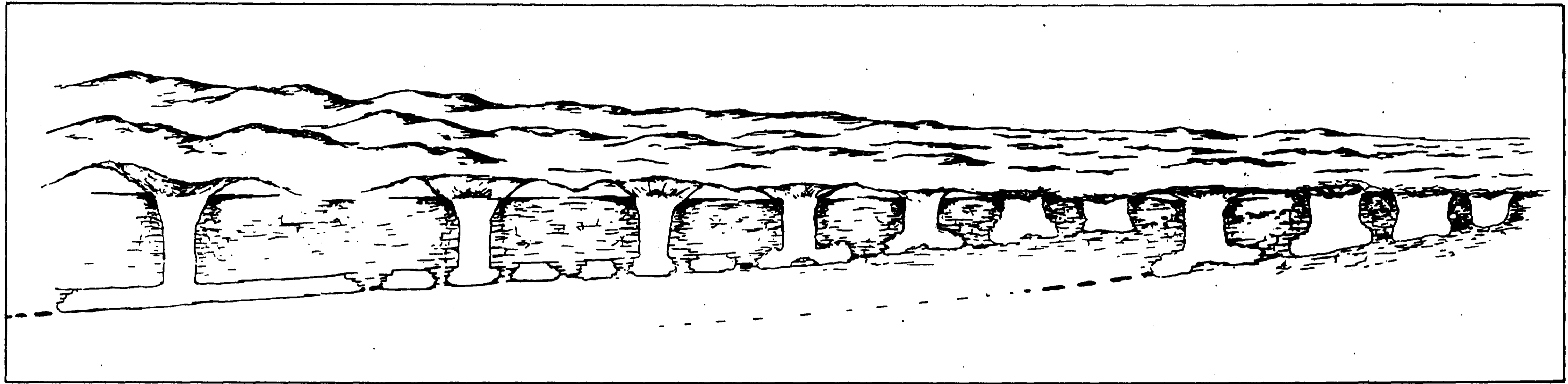


Fig. 11. PL 6 Krzemionki. System of deposit utilization of the exploitation field.

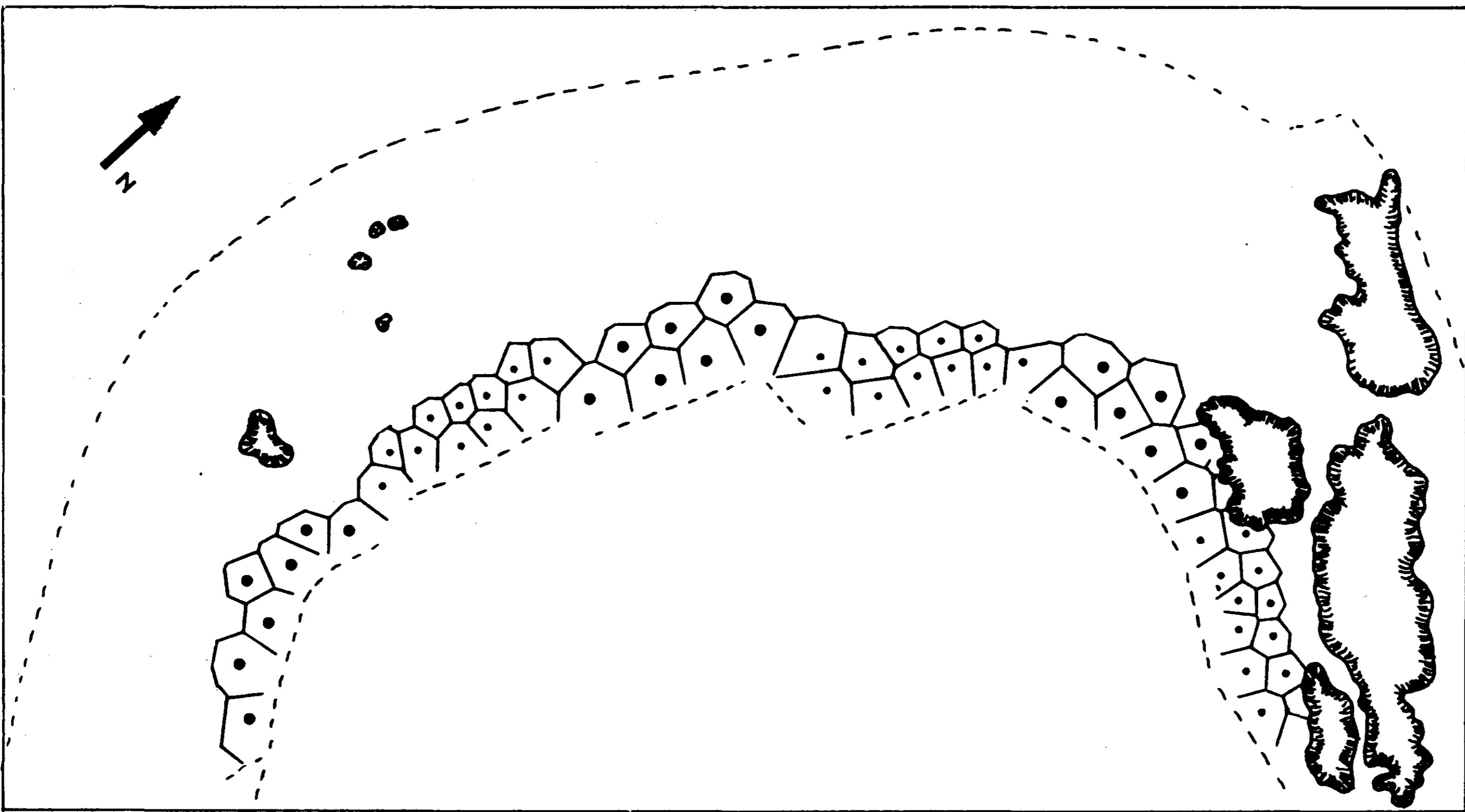


Fig. 12. PL 6 Krzemionki. Arrangement of chamber mines in the inner zone of exploitation field.

two flint beds present there, with the bottom bed being exploited by means of pit and niche mines. The top bed was exploited with all four mining systems known at Krzemionki. This model was subject to various modifications depending on the local geological-engineering conditions and the dip of rock layers (Fig. 12).

No large organizational units may be distinguished in the belt of pit and niche mines, which suggests that the place and time of exploitation there was a matter of spontaneous choice. This perhaps means that there were no legal regulations applying in this area to pit and niche mines, or that the original arrangement of mines was obliterated by later exploitation work.

The situation is different in the deep-mining belts. A particularly clear division into smaller units is discernible in the zone of chamber mines. These units (groups of mines) are separated by narrow stretches of empty terrain. The illustration shows several such mine groups. Only shafts of chamber mines are marked, and we see a succession of alternating 7- and 11-mine units.

From the available evidence we know that the subterranean excavations of chamber mines mesh: the fan-wise spreading mining fronts enter unexcavated areas of adjacent mines. Surprisingly enough, there are very few cases of penetration to an adjacent unit, and these occurred only at the extremities of exploitation areas. For this situation to be possible, the miners had to have detailed and direct knowledge of the layout of adjacent mines.

The existence of such knowledge means that there must have been information flow within a mining group. Mine shafts were filled in with rubble directly after

the last mining front was abandoned, this being indicated by the complete absence of flow traces at the bottom of the shaft. The mines were thus sealed off against any penetration that would not be controlled by the miners exploiting them.

The outer mines in each sector are separated from each other by exactly the distance equal to the maximum reach of mining work (measured from the shaft). This may perhaps indicate barriers in the direct flow of detailed information between the various groups exploiting these outer mines. The separating distance is the least and sufficient for the miners' safety in conditions when only general information about the mining work is available. Such a situation may indicate an absence of a collective system of exploitation organization.

On the other hand, the distances between the outer mining units in each of the separate sector remain constant. The borders between the various mine groups have thus been plotted according to criteria unrelated to exploitation organization, and have a modifying effect on this organization. One thus has to reckon with the existence in Krzemionki of legally defined fragments of the exploitation field assigned to separate mining groups employing distinct mining organization systems.

#### EFFECT OF THE KRZEMIONKI MINES ON NEOLITHIC SETTLEMENT

The processing and distribution of striped flint are issues far beyond the scope of this report. They have been tackled in separate publications (Borkowski *et al.* 1989:194–201, 1991:621–6; see also Balcer in this volume), and here we will dwell only on the Middle and Late Neolithic when the Krzemionki deposit was exploited by Funnel Beaker Culture (FBC) and Globular Amphora Culture (GAC) people.

The FBC settlement in and around Krzemionki is not significantly different from that in other areas (Kruk 1980), with large and medium sized settlement found alongside small camps. It is generally held that this model reflects an economy based on farming.

The only departure from the normal situation is here the large production settlement in Ćmielów, some 10 kilometers from the exploitation field in Krzemionki, and fully controlling the deposit there. The Ćmielów inhabitants were directly involved in flint extraction. The main production process took place in the settlement, and the scale of production greatly surpassed local needs (Balcer 1983:150–2). There is thus no doubt that the axes made there were intended for exchange. Their distribution was limited practically to the closest FBC settlements. We are thus here dealing with trade within a single group. It seems that in its time Ćmielów held the monopoly for extracting and processing the striped flint from Krzemionki.

There was also a different model linking FBC settlement to mines, perhaps belonging to a different period. This one is connected with the striped flint



exploitation fields in Borownia and Księża Rola Mała (*cf.* the article by Borkowski and Budziszewski in this volume). The small settlements around these fields indicates that the deposits were exploited, but the scale of raw material extraction and processing clearly indicate that only strictly local needs were being satisfied.

The GAC apparently represented a slightly different system of economy based on livestock, this being reflected in the settlement network, with seasonal camps as the dominant form of settlement. It is only from around Krzemionki that we know of several small settlements of a permanent nature. Although much smaller than the known FBC settlements, they nevertheless testify to the unique nature of this area. Although the presence of these permanent GAC settlements could have been due to changes in economy (greater role of agriculture), but it is more probable that they were connected with intense exploitation of the Krzemionki deposit, perhaps also with some form of control over flint extraction.

Unlike in the case of the FBC, in GAC's striped flint economy Krzemionki occupies a central position. The entire processing is done right here, in camps next to mines, and it is from here that the finished products were probably distributed. There are only scant traces of the settlements and camps outside the exploitation fields being linked to the mines. This suggests that it was only a small and highly specialized group of people who were engaged in mining. It may be that the division of the exploitation field into smaller units reflects not just ownership relationships pertaining to the field itself but also deeper group divisions.

The highly complex system of exploitation and processing in the GAC is reflected in the distribution of finished products, which is clearly of intergroup character. Although the flint axes and chisels were used as tool or combat weapons (traces of repairs), the functioning of a developed exchange system may be also explained in non-economic terms.

Towards the end of the Neolithic the system of exploitation and processing breaks down. Striped flint was used only sporadically in the Bronze Age, and thereafter the Krzemionki deposit had no visible effect on settlement in the area.

*Translated by Andrzej Lewandowski*

## REFERENCES

- Balcer, B. 1983. *Wytwórczość narzędzi krzemiennych w neolicie ziem Polski*. Wrocław.
- Bąbel, J.T. 1975. Zniszczenia, badania i ochrona rezerwatu w Krzemionkach, pow. Opatów. *Wiadomości Archeologiczne* 40:149–77.
- Borkowski, W. 1990. Diversenes of the flint mines at Krzemionki Opatowskie, Poland. Preliminary results of micromorphological analysis. In *Le silex de sa genese à l'outil — Cahiers du Quaternaire vol. 17, Actes du V Colloque international sur le Silex*, 225–31. Bordeaux.
- Borkowski, W. and R. Michniak 1992. Prahistoryczne pole eksploatacyjne (wybierkowe) w Krzemionkach. In *Materiały Krzemionkowskie* 1:11–36.



- Borkowski, W., W. Migal, S. Sałaciński and M. Zalewski 1989. Urgeschichtlicher Feuersteinbergbau im Gebiet von Krzemionki. Ein Bericht zum Stand der Forschung. *Praehistorische Zeitschrift* 64(2):164–207.
- 1991. Possibilities of investigating Neolithic flint economies, as exemplified by the banded flint economy. *Antiquity* 65(248):607–27.
- Kruk, J. 1980. *Gospodarka w Polsce południowo-wschodniej w V–III tysiącleciu p.n.e.* Wrocław.
- Krukowski, S. 1932. Pierwsza charakterystyka stanowiska kopalnianego Krzemionki na podstawie jego pozostałości naziemnych. *Wiadomości Archeologiczne* 11:53–7.
- 1937. Krzemionki Opatowskie. Pomnik górnictwa pierwotnego, prahistorii i przyrody nieożywionej. *Ziemia* 9(12):192–206, 247–76.
- 1939. Krzemionki Opatowskie. Warszawa.
- Migal, W. 1990. Organization and planning of flint mining operations in Krzemionki, Poland. In *Le silex de sa genese à l'outil — Cahiers du Quaternaire vol. 17, Actes du V Colloque international sur le Silex*, 197–9. Bordeaux.
- Sałaciński, S. 1987. Forschungsperspektiven der urgeschichtlichen Bergwerke des gebanderten Feuersteins in Krzemionki bei Ostrowiec Świętokrzyski. In *Internationale Konferenz über Silexgewinnung und Steinwerkzeug-Rohstoff Charakterisierung im Karpatenbecken*, vol. 2:257–62. Budapest — Sümeg.
- Sałaciński, S. and M. Zalewski 1986. *Krzemionki. Prahistoryczne kopalnie krzemienia pasiastego z neolitu i wczesnej epoki brązu.* Warszawa.
- Samsonowicz, J. 1934. *Arkusz Opatów ogólnej mapy Polski w skali 1/100000.* Warszawa.
- Zalewski, M. 1990. Study of settlement accompanying banded flint mines in Krzemionki, Poland. Archaeological exploration of environs of the “Kał Cebuli” karnst funell. In *Le silex de sa genese à l'outil — Cahiers du Quaternaire vol.17, Actes du V Colloque international sur le Silex*, 233–8. Bordeaux.
- Żurowski, T. 1960. Górnictwo krzemienia nad rzeką Kamienną. *Światowid* 23:249–79.
- 1962. Krzemionki Opatowskie. Pomnik starożytnego górnictwa. *Rocznik Świętokrzyski* 1:17–96.